1) General overview statements for Lyndsey & Fenix – E.S. of our concerns document
   a) The CSM contains much good work and site/area data. As a living document, our comments will assist in further inquiry and development of a more robust and conservative CSM and related transport models. Fundamentally, we want the CSM to reflect ***all*** real-world data observations, particularly given the spatially and temporally limited data set; similarly, we need the Navy team to treat available data as real, even if qualified.
   b) The CSM and derivative g.w. model do not seem to comport with measured groundwater gradients and as important, their directional variability. Factors that may explain include (CSM list below).
   c) The CSM appears to conclude that fast-track transport features are not a concern because of in-filling and predominant bedding dip directions. However, we believe there is a much wider range of dips present than measured in the CSM, and as indicated by the barrel logs, lava tubes and void zones are not universally in-filled. The CSM is non-conservative in this important regard, as fast-track transport features can allow for the rapid spread of contaminants into environment.
   d) Several lines of evidence indicate the likely historic migration of fuel contaminants to the west and northwest of RH ridge. Neither the CSM nor groundwater model reflect these data points nor does the CSM acknowledge that this is a likely plume migration scenario, thus rendering it non-conservative in this regard. The agencies recognize that individual data points can be qualified, but the totality of the groundwater quality and MNA parameter sets indicate these directions of contaminant transport, recognizing as well that the plume is only sparsely characterized.
   e) The LNAPL transport CSM is non-dynamic and cannot address questions regarding potential rates of transport as a function of the release size/rate, nor the ultimate distribution of LNAPL impacts and the associated potential risks to people and the groundwater resource. Given the flat groundwater gradients in the Red Hill area, LNAPL releases of sufficient volume to reach the water table will likely spread quickly and be influenced little by those groundwater gradients during the dynamic stages of transport. There is no linkage in the CSM or related estimations coupling the potential rates and directions of LNAPL transport with the capability of the Red Hill groundwater pumping system to contain a release.
   f) Related, the LNAPL CSM is predominantly uncharacterized and unparameterized, and little is known about actual historic transport. Historic groundwater detections at or near the fuel solubility limits and their persistence indicate that LNAPL is in direct or near-contact with groundwater. This important risk-management facet is not substantively discussed in the CSM.

2) Outline for SME comments & attachments

Top Ten – Grouped by CSM Dominant, followed by specific modeling & transport aspects

Items 1 – 5 (reordered) are primarily CSM aspects

1) Basalt strike-and-dip – one aspect of CSM that may explain g.w. flow in the real world v. CSM & model. Also critical to F&T considerations of potential directions of transport (LNAPL & g.w.)

2) Saprolite extents – one aspect of CSM that may explain g.w. flow in the real world v. CSM & model. The depths of the saprolite zones are not well-constrained except through geophysical interpretation and there are alternate interpretations of available boring logs. Further, saprolites are gradational and should not likely be viewed as a bulk HSU.
3) Cap rock, tuffs, sediments – another aspect of CSM that may explain g.w. flow in the real world v. CSM & model. A large block of materials is shown in the CMS Figure
4) Groundwater data – combined MNA and dissolved-phase detection frequency distribution indicate that transport has been predominantly west & NW of RH ridge (see also below F&T)
5) Coastal marine discharge – another likely real-world condition (Kelly work & others) that explains more complex flow with smaller and more variable gradients

Items 6 – 7 – Model Calibration & Validation

6) Tunnel inflows – the groundwater model does not reflect the variable in-flow into the Red Hill Shaft. Better tuning and calibration to these observations may better the model reliability and understanding of the underlying flow and transport system.
7) Calibration – heads, gradients – the groundwater model suite, at present, diverges from measured head differentials by one- to two-orders of magnitude. As a result, modeled groundwater flow is dominated by ridge-to-ocean flow directions (mauka-to-makai) and at magnitudes inconsistent with measurements. The model will not be a reliable tool absent much better calibration (see CSM items above regarding hydrogeologic model)

Items 8 – 9 – Contaminant F&T

8) Preferential pathways – void features in this shield volcanic setting will potentially allow for rapid transport of both LNAPL and dissolved-phase contaminants. These include lava tubes, bedding plane structures, fractures, etc. While mentioned in the CSM, there is no comprehensive of specific discussion of key facets (see ITRC fracture CSM).
9) LNAPL F&T & Characterization – the CSM places too great a certainty on the LNAPL distribution as an outcome of the 2014 release and generalized historic releases. Site data indicate that the 2014 release propagated past the in situ vapor probes from the center to the outside of Tank 5, with only a minimal and delayed response at the inner probe closest to RHMW02.
10) LNAPL F&T approach – the non-dynamic LNAPL F&T approach cannot estimate the outcomes of potential tank farm releases. Aspects like rates and distances of transport, whether releases can be captured through pumping, and other dynamic considerations are unaddressed at present. The CSM needs to more broadly consider these facets, as well as how to best parameterize those to site specific conditions.

Major Points of Contention and Concern

The following are major points of contention and concern that are shared by the SMEs to varying degrees and to the extent each has technical expertise in each subject area. Where any particular contention or concern is expressed by only a subset of SMEs – due either to subject-matter expertise or limitations of local knowledge, or lack of detailed pursuit of that specific topic to-date, for example – this is expressed by including the initials of the particular SME(s) in parenthesis.

- Items in black font are considered to be potentially "remediable" between the interim and final deliverables if the interim deliverables are unsatisfactory and there is willingness of the Navy contractors to do so.
- Items in red font are either (a) *not* considered to be potentially "remediable" between the interim and final deliverables if the interim deliverables are unsatisfactory or (b) could be remedied but appear unlikely to meet with a willingness of the Navy contractors to do so.

Conceptual Model Concerns

Important features of the hydrogeologic system do not appear to be formally or quantitatively represented in the CSM or included in the interim numerical groundwater model or LNAPL model or are not represented in a manner consistent with regulator SME understanding. Examples are:

1. Dip and strike of the lava units: Navy CSM suggests southward dip at over 10 degrees, whereas regulator SMEs believe the direction to be southwestward at a dip of between 3 and 5 degrees. It is unclear how this is represented in the model. The steeper more southerly dip is likely to be non-conservative in terms of potential risk to Halawa Shaft.
2. Presence, frequency, role of enhanced flow-transport features such as lava tubes: has been discussed, but no materials presented to-date indicating such features are explicitly considered.
3. Character of the cap rock along the shoreline of the harbor (i.e., downgradient boundary) is in dispute among the various parties (USGS, BWS, regulators and Navy), and not currently well-conceived, characterized, or represented.
4. Presence, character and role of the buried craters and salt lakes located primarily southwest of Red Hill has not been described, considered or incorporated into analyses either in base model or sensitivity analyses. These areas were evaporative "lakes" at one time, that exhibited fresh-water strongly artesian conditions beneath them. They likely form a barrier to flow and result in bifurcation.

Groundwater Model Development and Application

Several aspects of the development and application of the interim groundwater model do not appear to be complete, thorough, or sufficiently rigorous to support the intended purpose. Examples are:

1. Calibration: the complexity of the natural system, and relatively low number of monitoring locations, provide insufficient data for calibration to provide confidence that predictions are reliable, or that a "good" model has been developed.

2. Calibration: the calibration appears to show a bias preponderance for flow toward Red Hill shaft due to simulated hydraulic gradients that are 10 to 100 times higher than measured gradients in that direction. This bias is non-conservative in terms of potential risk to Halawa Shaft.
3. Sensitivity analysis: individual sensitivity analyses have identified parameter combinations and structural differences that appear to improve the model, but these have not been incorporated into the "base" interim model.
4. Capture zones: incompleteness of capture (zone of contribution) depictions for water sources when using a limited number of particle paths versus a full 3D particle cloud.
5. Boundaries: upgradient (NE) boundary held constant regardless of climatic conditions, and sensitivity untested to-date?
6. Saprolite: the uphill (inland) extent of the valley-fill saprolite and/or the degree of its penetration of the water table, and its effects as a flow barrier may be exaggerated in a manner that is non-conservative in terms of potential risk to Halawa Shaft via flow-around / under-flow on the northern/eastern limits.

<u>LNAPL Model Development and Application</u>

Several aspects of the development and application of the interim groundwater model do not appear to be complete, thorough, or sufficiently rigorous to support the intended purpose. Examples are:

1. Homogeneous (equivalent porous media [EPM] assumption) is not applicable and is non-conservative in terms of likelihood of LNAPL to reach, impact, and migrate within groundwater
2. Unverifiable: model as constructed cannot be "calibrated" corroborated or verified, as it does not simulate any specific release or event, but rather is a hypothetical box-model. It cannot be compared with data.

<u>Historical Data Interpretation</u>

Interpretations of historical data presented to-date conflict with interpretations and / conclusions of the regulator SMEs. Examples are:

1. Combined evaluation of attenuation data: the interpretations presented to-date suggest very high attenuation capacity. This assumption is non-conservative in general and specific terms.
2. Specific interpretation of groundwater sample data:
    a. Absence of high-concentration detections in the small widely spaced monitoring network is not proof of absence of impacts but is interpreted as such by the Navy.
    b. Navy dismissal of some detected results, even if justified, does not appear to dismiss all detected results: regulator conclusion that if any detects are real, then impacts have occurred, seems not to be acceptable to navy contractors, but justification for dismissing all detects not yet provided
    c. Navy at one time allowed for "alternative hypotheses" of at least equivalent likelihood of LNAPL impact vs. no impact, but now appears to strongly favor no-impact interpretation.
3. Specific interpretation of vapor data: in process of evaluating independently now, however, location of vapor points below tank pads may lead to ambiguous results. Navy contention that vertical profiles indicate negligible vertical LNAPL migration is as yet unverified

4. Specific interpretation of temperature data: while temperature profiles may reflect NSZD processes, cannot conclude that all NAPL (or some specific proportion thereof) therefore pools in a limited vertical horizon and extends no closer to the water table. Temperature profiles do not definitely indicate LNAPL hasn't impacted water table.